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UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 1499

Washington, D. C. ▼ June, 1929

TIMBER GROWING AND CUTTING PRACTICE IN THE LODGEPOLE PINE REGION

MEASURES NECESSARY TO KEEP FOREST LAND PRODUCTIVE AND PREFERRED PRACTICE FOR OBTAINING FULLER AND MORE VALUABLE TIMBER CROPS

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By

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Introduction by

W. B. GREELEY, Formerly Forester, Forest Service

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By M. W. THOMPSON, *Assistant District Forester, Forest Service*

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INTRODUCTION

Forestry in the United States is no longer merely a theory or a subject for discussion; it has gotten down to concrete things in the woods. Nor is the growing of timber confined to public lands; it is gradually making headway on land in private ownership. It is becoming an art of land management, expressed in practical measures for protecting forest growth from fire and other destructive agencies, for logging timber so as to produce a new crop of wood, and for planting forest trees on denuded areas. The value of timber, with other economic considerations, is causing landowners more and more widely to study the possibilities of reforestation. These developments have created a demand for information on the timber-growing methods which are adapted to the various types of forest growth in the United States.

Timber culture, like the growing of farm crops, is necessarily governed in any country by its soil and climate, by the requirements of the native forest trees, and by local economic circumstances. Lessons may be drawn from the experience of other countries, as the United States has drawn upon the forestry practices of Europe; but

profitable methods of growing timber, particularly under the wide range of forest types and economic conditions in the United States, can be evolved only from our own experience and investigation. Hence, to meet the demand for information on practical ways and means of growing timber in the various parts of the United States, it is important that the results of our own experience and investigations to date be brought together and set forth in the clearest possible way.

This the Forest Service has attempted to do in a series of publications dealing with the 12 principal forest regions of the United States. The information presented has been gathered from many different sources. An effort has been made to bring together all that any agency has yet learned or demonstrated about the growing of timber, and the results have been verified as far as possible by consultation with the forest industries, State foresters, and forest schools. These publications thus undertake to set forth, in a simple form, what are believed to be the soundest methods of reforestation as yet developed in our common experience and study in the United States.

The Forest Service claims no finality for the measures proposed. In every country forestry has come about through a gradual evolution. Much is still to be learned about growing timber under American conditions. As time goes on, research and practical experience will add greatly to the success and certainty of the measures carried out in our woods, just as American agriculture and manufacturing processes have been perfected through experience and study. But we know enough about growing timber to go right ahead. Believing that the forest owners of the United States are ready to engage in timber growing on a large scale, the Forest Service has endeavored to place before them in concise terms the best suggestions and guides which the experience of this country to date affords.

In these publications the measures proposed for a particular forest region have been arranged in two general groups. The first includes the first steps in forestry, or the minimum requirements of local physical conditions, to prevent timberland from becoming barren. These measures, in which the prevention of fire is of outstanding importance, represent, broadly speaking, the least that must be done to keep forest lands productive. As Mr. Thompson points out, even these very simple things will bring back good stands of timber on many of the forest lands in the lodgepole pine region. By and large, however, they will seldom satisfy the landowner who wishes to make the most out of his property in timber culture. They represent rather the dividing line between keeping land in forest of some sort and allowing it to revert to a barren, treeless condition.

The second group of proposed measures constitutes what may be called desirable forest practice in the lodgepole pine region. These are designed to grow reasonably complete crops of the more valuable timber trees and to make full use of the productive capacity of the land. It is impossible to frame any set of measures that are adapted to the needs of all individual holdings or industrial enterprises. Hence, Mr. Thompson has attempted only to outline the more fundamental things, with illustrative methods of forest practice. The

details of forestry, like the details of agriculture or engineering, call for expert study in working out the plans and methods best adapted to a particular tract of land or a particular business.

It is of course not practicable to draw a hard and fast line between the first steps that will maintain some degree of productiveness on forest land and the more complete measures that will bring the quantity and quality of wood produced up more nearly to ideal results. The two general types of forest practice grade into each other in a common-sense and practical résumé of the various steps in timber growing that will be most helpful to the man in the woods. Mr. Thompson's bulletin has been written primarily for the men to whom timber growing is a concrete business and logging problem. At the same time it will have value for the everyday reader who is interested in forestry as an important phase of land use in the United States and in the public policies designed to bring forestry about.

The Forest Service has tremendous faith in the commercial promise of timber growing to American landowners. The law of supply and demand is working steadily to create timber values which in large portions of the United States will pay fair returns on forestry as a business. The economic history of other countries which have passed through a cycle of virgin-forest depletion similar to that which the United States is now traversing points to the same conclusion. The time is approaching when forestry, and forestry alone, will supply the enormous quantities of wood demanded by American markets. The fundamental laws of business must in the nature of things so operate as to enable the markets for forest products to be supplied at a profit to the grower of timber. The returns being obtained from this form of land employment at many points in the United States show that this relationship between the value of timber and the cost of producing it is already coming about.

To the men who own forest-producing land in the United States or who are engaged in industries which require timber as raw material, forestry now offers a commercial opportunity. Satisfactory returns from forestry can not be promised in sweeping terms any more than returns from the manufacture of lumber or paper, or from running a railroad or operating a mine. But the opportunity for profitable employment of capital and business talent in the growing of timber merits the same consideration and the same expert guidance as any other industrial opportunity. This applies with special force to the commercial institutions in the United States which have made large capital investments in manufacturing plants and distributing organizations, dependent for their maintenance upon a future supply of forest-grown material. It applies no less to the owners of land, in large tracts or farm wood lots, the earning capacity of which lies chiefly in growing trees and which, without tree growth, will become either a doubtful asset or an outright liability. The Forest Service earnestly asks the forest landowners of the United States to determine for themselves, with the same care with which they would approach any other business problem, whether timber growing does not offer a commercial opportunity which they should grasp.

On the other hand, the general public has a vital interest in keeping the forest lands of the United States productive. The loss of forest growing areas in the Rocky Mountain region not only saps

future prosperity and economic development through a local shortage of timber; it directly imperils the limited water resources which are the lifeblood of agriculture and are being more and more widely used for hydroelectric power and municipal supply. A responsibility rests upon the owner of forest land to employ every practicable means for protecting these public interests, recognizing the right of the public to require such measures of forest protection and conservation as will safeguard the general welfare.

At the same time, it is incumbent on the Rocky Mountain States to aid the landowner in reforestation. This is due to the general interests at stake in timber and water supply. Aside from care and foresight in the management of State-owned forest lands, public aid is particularly needed in the protection of all forest and mountain areas from fire and in the encouragement of tree planting. The cooperation of the Federal Government in these activities is offered under the Clarke-McNary Act. While much progress has been made toward state-wide forest protection in the lodgepole pine region, the present efforts need to be materially strengthened and extended. That is primarily a duty of the States themselves.

Nor does the Forest Service overlook its own responsibilities. These are particularly great in the region covered by Mr. Thompson's report because of the large proportion of its forest and mountain areas which are within national forests. The general type of intensive timber culture which Mr. Thompson outlines is the goal which has been set up in the management of the national forests. The conservation of water supply is another factor which the Forest Service strives to keep constantly to the front, not only in timber cutting and tree planting but also in the administration and control of grazing.

Aside from its direct responsibilities as custodian of public lands, the Forest Service recognizes its broader obligation to assist the States and private owners in the lodgepole pine region, in so far as it may, in their problems of forest protection and renewal. The joint protection of intermingled ownerships, to which the report refers, is a case in point. Cooperation is the key of the Federal forestry policy written into the Clarke-McNary Act. The Forest Service holds itself ready not only to discharge the specific duties prescribed by this law, but also, as a good neighbor with the interests of the region at heart, to aid the States and landowners of the Rocky Mountains in promoting forestry in any way that may be open.

W. B. Greeley.

THE REGION AND ITS TIMBERLANDS

The region covered by this bulletin, as the name indicates, is roughly the commercial range of lodgepole pine in the Rocky Mountain and intermountain regions. (Fig. 1.) It includes that portion of Montana east of the Continental Divide and extending to the

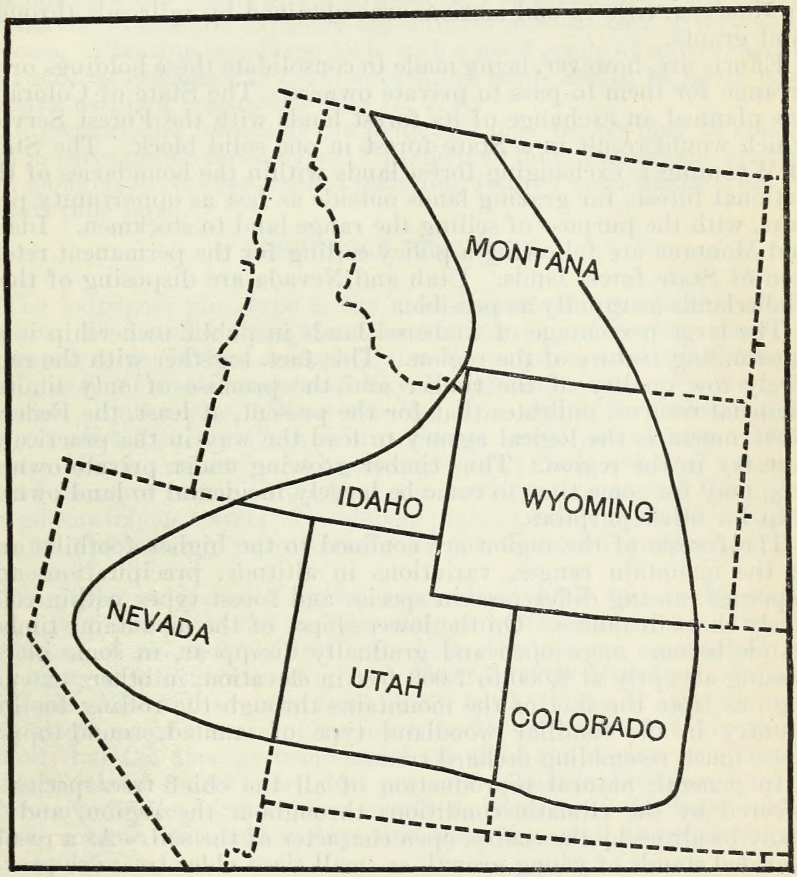

FIGURE 1.—Commercial range of lodgepole pine in the Rocky Mountain and intermountain regions

western yellow pine type in the eastern portion of the State; all of Wyoming, except the Black Hills region along the eastern boundary of the State; the fringe of forests in eastern Idaho south and east of the junction of the Bitterroot Range with the Continental Divide; Colorado and Utah down to the western yellow pine type in the

southern portion of these States; and Nevada east of the east slope of the Sierras.

The timbered acreage within this region is roughly estimated at slightly over 23,000,000 acres. Approximately 87 per cent of this acreage, outside of the national parks, is included in national forests; about 5 per cent is in the public domain or within Indian reservations; approximately 1 per cent is in State ownership; and about 7 per cent is privately owned.

The tracts in private and State ownership are, for the most part, intermingled with national-forest lands or located immediately outside the boundaries. Many of the timbered areas held by the States are scattered school sections; also in certain localities, particularly in Montana, title to odd sections was obtained by railroads through land grants.

Efforts are, however, being made to consolidate these holdings or to arrange for them to pass to private owners. The State of Colorado has planned an exchange of its forest lands with the Forest Service which would result in a State forest in one solid block. The State of Wyoming is exchanging forest lands within the boundaries of the national forests for grazing lands outside as fast as opportunity permits, with the purpose of selling the range land to stockmen. Idaho and Montana are following a policy calling for the permanent retention of State forest lands. Utah and Nevada are disposing of their timberlands as rapidly as possible.

The large percentage of timbered lands in public ownership is an outstanding feature of the region. This fact, together with the relatively low quality of the timber and the promise of only limited financial returns, indicates that for the present, at least, the Federal Government is the logical agency to lead the way in the practice of forestry in the region. Thus timber growing under private ownership may for some time to come be largely incidental to land ownership for other purposes.

The forests of the region are confined to the higher foothills and to the mountain ranges, variations in altitude, precipitation, and exposure causing differences in species and forest types within relatively short distances. On the lower slopes of the mountains timber stands become more open and gradually disappear, in some places ceasing abruptly at 6,000 to 7,000 feet in elevation, in others extending out from the foot of the mountains through the rolling foothill country in the familiar woodland type of stunted, round-topped trees, much resembling orchard trees.

In general, natural reproduction of all the chief tree species is favored by the climatic conditions throughout the region, and in many localities by the coarse, open character of the soil. As a result, crowded stands of young growth or small-sized older trees are prevalent. As compared with that in other regions, the timber is small and of slow growth—facts which influence forestry practice to a great degree.

On a conservative estimate, 1,230,000 acres of the forest land is classed as denuded, either supporting no tree growth of present or prospective commercial importance or so barren of trees of cone-bearing size as to preclude natural reforestation for at least 30, and more likely 50 or even 100 years. The cause of this condition, with

the exception of an extensive area in the vicinity of Butte and Anaconda, Mont., where smelter fumes have killed all tree growth, is fire, either by itself or following cutting.

Aside from the killing of timber by smelter fumes, most of the denudation took place prior to 1905. Fire protection in recent years has not only largely prevented any considerable increase but, through the encouragement of new growth, has actually brought about a reduction in the devastated area. However, restocking has been limited to the immediate vicinity of islands of trees or individual trees of seed-bearing size which escaped fire. In such locations reproduction of conifers has usually appeared, provided aspen or brush cover has not been too dense, or the growth of weeds and grass too heavy, or soil conditions and exposure too unfavorable—at best, a very slow process. Planting on a large scale with a good grade of nursery stock will still be necessary if these devastated lands are to be made productive within a reasonable time (*8*, *17*).[1]

In general, the forests of the lodgepole pine region may be classified in three major forest types:[2] Lodgepole pine, Engelmann spruce, and Douglas fir, the last-named including limited areas of the western yellow pine type.

LODGEPOLE PINE TYPE

The lodgepole pine type is the most important type in the whole region. It includes those tracts containing 50 per cent or more of lodgepole pine (*Pinus contorta*), usually in pure, even-aged stands. Douglas fir (*Pseudotsuga taxifolia*), Engelmann spruce (*Picea engelmannii*), limber pine (*Pinus flexilis*), and alpine fir (*Abies lasiocarpa*) often intermingle, but in relatively small proportions. Blue spruce (*Picea pungens*) and bristlecone pine (*Pinus aristata*) are also found to some extent throughout the southern portion of the type. Large continuous stands of lodgepole pine, of fairly uniform volume, are an outstanding characteristic of the timbered portion of the region.

This type ranges in elevation from about 6,000 feet in Montana and Idaho and 7,000 feet in Wyoming and Colorado, to a maximum elevation of about 9,500 feet. Its best development is reached in Wyoming at altitudes varying from about 7,500 to 9,000 feet. Extensive areas that will average from 12,000 to 15,000 board feet per acre and single acres containing as much as 25,000 board feet are to be found; but the average commercial stand of the region as a whole contains about 10,000 board feet per acre. This is, however, hardly expressive of the total volume involved, because of the large additional volume contained in tops and trees too small to be measured in board feet.

Dense, even-aged stands are characteristic of the type. (Pl. 1, A.) In fact, in many instances they are seriously crowded and in a stagnant condition. (Pl. 1, B.) This is brought about largely as a result of the persistence of the species in reestablishing itself after fire. However, the trees of these even-aged stands are not of uniform size, because the stronger individuals crowd and hold back the

[1] Italic figures in parentheses refer to publications listed in the bibliography, p. 33.

[2] Forest type is a term used to characterize forested areas throughout which a certain number of tree species occur in fairly consistent relationships.

weaker, the latter persisting, nevertheless, for long periods, even though they may make an extremely slow growth.

ENGELMANN SPRUCE TYPE

The Engelmann spruce type, as considered here, includes those stands which contain 50 per cent or more of Engelmann spruce with varying mixtures of alpine fir, white fir (*Abies concolor*), lodgepole, limber, and bristlecone pines, whitebark pine (*Pinus albicaulis*), Douglas fir, and blue spruce. The occurrence of bristlecone pine in mixture with Engelmann spruce is limited to Colorado and Utah; whitebark pine is found in association with Engelmann spruce only in Montana, Idaho, and Nevada. Alpine fir is almost invariably present, but under natural conditions seldom predominates. Spruce is only occasionally found in pure stands.

Engelmann spruce occurs typically in uneven-aged stands. It withstands shade well, and reproduction is nearly always present. Seedlings persist even in dense shade; and though they may make very slow growth, they respond readily when released.

Toward the lower limits of tree growth the type follows stream courses; at intermediate elevations it spreads to other cool, moist situations; from here on up to timber line (10,000 feet or higher) it occupies any site. For the protection of watersheds it is by far the most important type in the region.

Maximum stands are found at elevations varying from 9,000 to 10,000 feet. While yields of 60,000 feet an acre have been reported, the average for the commercially timbered areas would run about 15,000 board feet to the acre.

DOUGLAS FIR TYPE

The Douglas fir type includes stands containing 50 per cent or more of this species, and also the small and scattered areas of the western yellow pine type within the region. Lodgepole and limber pines, western yellow pine (*Pinus ponderosa*), Engelmann spruce, and alpine fir are the species generally found in varying proportions in the Douglas fir type. Other species, such as white fir, bristlecone pine, and blue spruce, are associates in the southern portion of the region.

The type ranges from the lower limits of tree growth up to approximately 9,500 feet. The best stands are found at altitudes varying from 7,500 to 8,500 feet. In contrast to the lodgepole pine type, Douglas fir usually occurs in stands of comparatively small area on cool, north slopes at lower elevations and on warmer sites at the higher altitudes. In the northern part of the region, particularly in Idaho, the type extends over larger continuous areas, and there attains its best development for the region. Stands in Idaho run as high as 35,000 board feet to the acre, but the average volume on the better-timbered areas is about 10,000 board feet. The volume on the commercially timbered lands in the southern portion of the region averages only 5,000 to 7,000 board feet an acre.

The stands, which are usually uneven-aged, ranging from seedlings to large overmature trees, contain large quantities of alpine fir or white fir, inferior species that in the seedling stage are better able to

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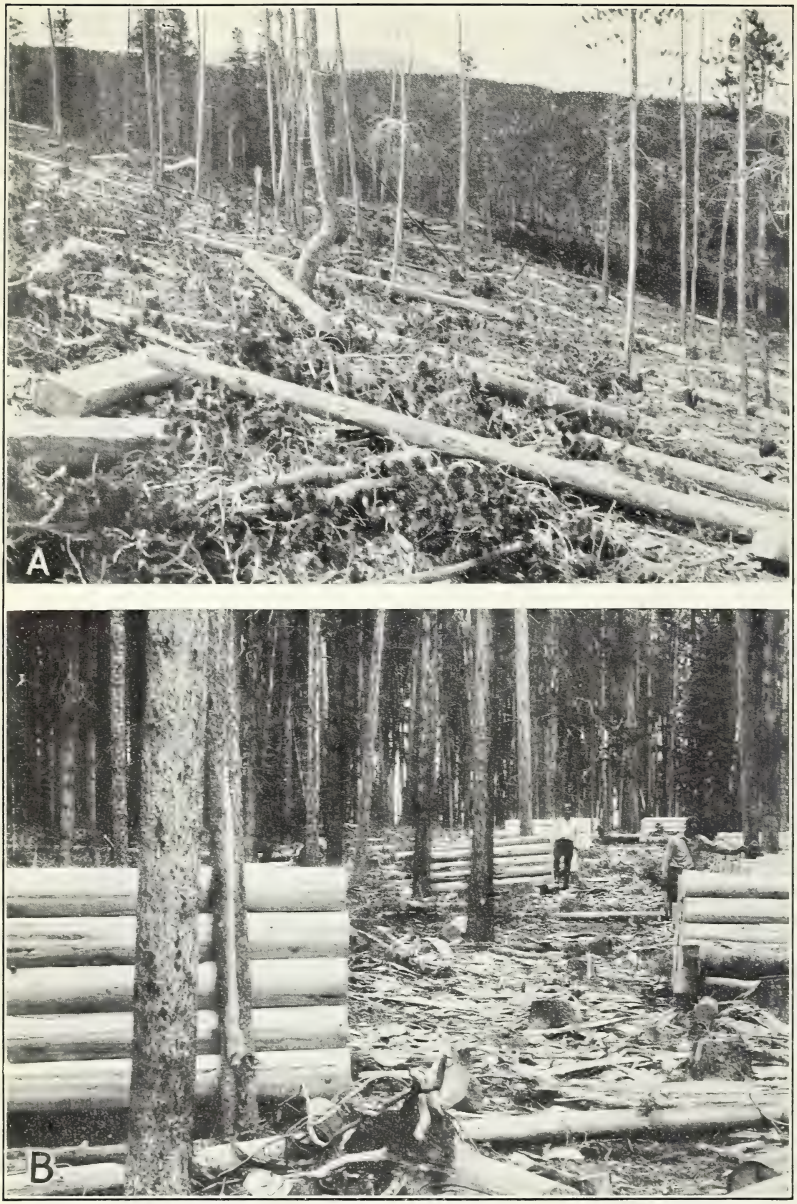
TYPICAL LODGEPOLE PINE STANDS

A.—Dense even-aged stands with little reproduction on the ground are characteristic of the older timber in the lodgepole pine type.
B.—Overcrowded stagnant stands are also typical, brought about largely by the persistence of the species in establishing itself after fire.



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LODGEPOLE PINE IS A FAVORITE IN THE HEWN-TIE INDUSTRY

A.—On accessible areas where there is a market for small products heavy cutting is the rule. Hewn railroad ties, telephone poles, mine props, and mine ties are marketed—in fact, all material to a 4-inch top diameter is utilized.

B.—A greater volume is utilized for railroad ties than for any other purpose. The adaptability of lodgepole pine for hewn railroad ties is shown by the pole ties produced in a typical stand.

stand shade than Douglas fir. Also, if the more valuable species are cut heavily, a practice common on private land, the inferior species tend to increase. A selective system of cutting that includes a heavy removal of inferior species works out more satisfactorily in producing valuable future crops.

NATURAL AND OTHER FACTORS AFFECTING FOREST CULTURE

SLOW RATE OF GROWTH

Largely on account of the high altitude of the timbered portion of the region and the resulting short growing season, the rate of growth of the various species is generally slow. Rocky site and shallow soil are in many places, however, even more restrictive of growth. Another very important consideration in this connection is the abundant reproduction and consequent crowded condition prevailing in many stands, resulting at an early age in stagnation or slow growth. The low productivity of the land due to these various factors, together with the high logging costs in a region of rugged topography, make it difficult for timber to be grown here in competition with that grown in other regions, such as the South and the Northwest, where it makes more rapid growth and requires a shorter rotation period. However, the prospective decreases in supply of timber from other sources, together with high freight charges, will tend to make the situation less acute and the practice of forestry by private owners more attractive in the future. The lodgepole pine region will not only have local markets to supply, but can assist in meeting the requirements of the Plains States to the east.

VALUE OF THE TIMBERLANDS FOR VARIOUS USES

DEMAND FOR TIMBER AND WOOD PRODUCTS

Railroad ties, mine props, mine timbers, telephone poles, and lumber are the important timber products marketed in this region. (Pl. 2.) More material is utilized for railroad ties than for other purposes because of the demands of the local and transcontinental railroad lines and the fact that a large portion of the trees in an average stand are of tie size.

Coal and metal mines insure a limited regional market for mine timbers and mine props, which freight charges make it impracticable to ship long distances. These products are obtained from tops of trees cut for railroad ties and saw logs, and also from entire trees of suitable size. Small trees may well be put to this use if they are mature or if their removal is warranted as a thinning measure. But where a favorable market has caused owners to cut small trees for mine props regardless of rate of growth or condition, there is a loss not only in the future increment of the more thrifty trees, but also in the waste of other material which should instead have been salvaged in the form of thinnings or as by-products from other operations. The fact that markets for small material generally are insufficient to absorb anywhere near the amount that could be supplied from cuttings made as improvement measures, makes this waste a particularly

important consideration. In fact, an additional market for small-sized material such as might be utilized for fence posts or paper pulp is the greatest need of the entire region, from the standpoint of good silvicultural practice.

The lumber consumption of the region greatly exceeds local production. This situation exists because local species are principally suitable for the manufacture of only the common grades, and because of the comparatively low prices at which lumber from the Northwest can still be obtained. However, as the population and industries increase, local timber stands will be drawn upon in constantly increasing amounts. To prepare for this increased demand, and because it is desirable from an economic standpoint to produce timber products as near as may be to the centers of consumption, the possibilities in more intensive and more profitable growth of timber must be given suitable consideration. The welfare of the forests affects the future growth and prosperity of the whole region.

GRAZING USE

In the timbered portions of the region, grazing lands consist of grass or sagebrush slopes, mountain meadows, and the more sparsely stocked forest land. Grazing in the average timbered area is rendered impracticable by such obstacles as steep and rocky slopes and dense stands of trees and young growth. It would seem that in many instances grazing might form an important part of forest management, at least while new stands of timber are growing up to a size profitable for cutting; but as a matter of fact grazing can not be counted upon as a resource to any appreciable degree, and this mainly because of the results of continued fire protection. As fire is kept out, the lightly timbered areas are becoming more fully stocked, and open lands are being gradually invaded by the forest. As a consequence of this steady shrinkage in the available forage lands within the timbered sections, annual returns from grazing on these lands will never be of much importance in meeting the current expenses of growing timber crops.

On the other hand a number of tests and observations have conclusively demonstrated that such grazing as there is has practically no ill effect upon the forest. In fact, it generally assists greatly in reducing fire danger through the breaking up and treading down of the ground litter. Whatever injury is attributable to grazing is found chiefly on cut-over or burned-over tracts which receive the greatest amount of use. Sheep grazing is likely to be more harmful than cattle grazing, but in certain places, such as driveways, damage from this source can not be eliminated. In any event, the damage will be practically negligible if the number, distribution, and handling of stock are properly regulated to the permanent capacity of the range. If overgrazing is thus avoided, damage to young trees will be slight.

USE FOR WATERSHED PROTECTION

Engineers have said of this region that, even if every drop of water which falls in the mountains could be conserved, the volume would still be insufficient to irrigate all of the arid lands requiring water in order to be productive. This emphasizes the importance of maintain-

ing forest cover, which is a powerful agent in regulating and conserving the flow of water. Forests of the lodgepole pine region are located on the headwaters of innumerable important streams supplying irrigation water for an enormous acreage in a number of States, including several far removed from the forested lands.

Although it would be difficult to place a value on this use of the forest, its importance is obvious enough, as is also the interstate character of the benefits to be derived. It is fitting that the Federal Government should continue to take the lead here in watershed conservation through fire protection and the practice of forestry.

RECREATIONAL USE

The maintenance of fish and game resources is an important consideration in the recreational use of the forest, a use that is becoming of increasing importance to residents of cities and towns throughout the country. Nor is this use of the forest by any means inconsistent with the practice of forestry. Properly regulated timber cutting increases the attractiveness of the forest at the same time that it promotes forest growth. In many ways, as experience has shown, good forest practice can be and should be correlated with recreational use. If this is to be accomplished, it is certainly essential that forests be maintained in a productive condition, and that the forested area be not reduced.

Every form of recreational use is dependent upon the protection of the forest. People do not camp on barren hillsides nor build summer homes on the open plains. Most kinds of game are dependent upon the perpetuation of the forest for a home, as are fish on the well-regulated flow of forest streams. In these and many other ways protection, which is the first essential of the practice of forestry, automatically extends its benefits to the human users of the forests.

EXTENT AND MANNER OF LOGGING

The cutting which has taken place in different localities is closely related to the length of time adjacent settlements have been developed. The eastern-slope forests, tributary to the Great Plains region, particularly in Colorado, were drawn upon heavily in the early days, and the same is true in the vicinity of highly developed mining camps, such as Cripple Creek and Leadville, Colo.; Butte, Anaconda, Red Lodge, and Helena, Mont.; and Bingham and Clear Creek, Utah. No organized fire protection was given to the forests until 1905, and fires were often permitted to burn unchecked until extinguished by natural causes. Lodgepole pine has recovered best from this heavy use and lack of protection; the greatest lasting damage resulting from the early cuttings seems to have occurred in the spruce and fir types, where extensive fires swept the remaining slashings so thoroughly that the forest even after an interval of 60 years or longer has not yet been completely reestablished. The slopes of Pikes Peak offer one of the most striking examples.

The bulk of the cutting at present is on national-forest lands. Not more than 20 per cent of the production is from other areas, and this percentage will probably decrease steadily, since the supply

is coming from the more accessible lands in private and State ownership, and the private lands at least are being cut over so heavily that they will not yield another crop for many years.

Power logging is not practiced in the lodgepole region; animal logging is the standard practice in all types and localities regardless of land ownership. This presents several advantages for the perpetuation of the forest. Much of the logging takes place during the open season, and this tends to expose the mineral soil and thereby to create in all types conditions favorable for natural reproduction. Another important and desirable feature of animal logging is that it does not involve a source of fire, as other methods usually do. No logging railroads are used—a very important factor from a fire-protection standpoint. Particularly in Wyoming, timber products are transported quite extensively by flumes and stream-driving where conditions are such that these methods are practicable (*4*).

Practically all operations are conducted on a small scale. An annual cut of 5,000,000 board feet or more a year is attained by only a very few producers. Railroad ties, generally hewed, are produced in all of the larger operations.

FIRE DANGER AND PRESENT PROTECTIVE AGENCIES

In the lodgepole type, where stands are dense at all ages and high winds recur frequently, fires are usually intense and crown fires develop much more readily than in other types of the region. The thin bark of the lodgepole pine affords little protection, with the result that serious damage may be done even by surface fires that may not kill the larger trees.

Although fires occur much more rarely in the Engelmann spruce type than in the lodgepole, protection from fire is more important from the standpoint of continuous productivity, for an extensive severe burn will preclude natural restocking. (Pl. 3.) The absence of stored seed and the readiness with which grass or weeds restock the burned-over areas account for this. Fortunately, the risk of fire starting is not, as a rule, as great as in the other types, largely because this type is located on the more moist sites and at the higher elevations. The northern portion of the region is an exception, for there Engelmann spruce occurs at lower elevations and is subject to greater drought and fire hazard.

In the Douglas fir type the situation is much the same as in the lodgepole pine, except that Douglas fir, having a thick bark, is not subject to such serious damage.

The record of forest fires in the national forests of Colorado, Wyoming, and Utah shows that an average of 2 acres in each 10,000 is burned over annually. This area does not include the entire region under consideration, but embraces a large portion of it, and the record is considered as generally applicable.

Up to and including 1921, railroads constituted the most frequent source of fire and were responsible for a large portion of the damage. Since that time losses from this source have been largely eliminated. Experience has shown that, where the railroads use reasonable care to keep their rights of way clean, install and adequately inspect efficient spark arresters on coal-burning engines, and maintain non-

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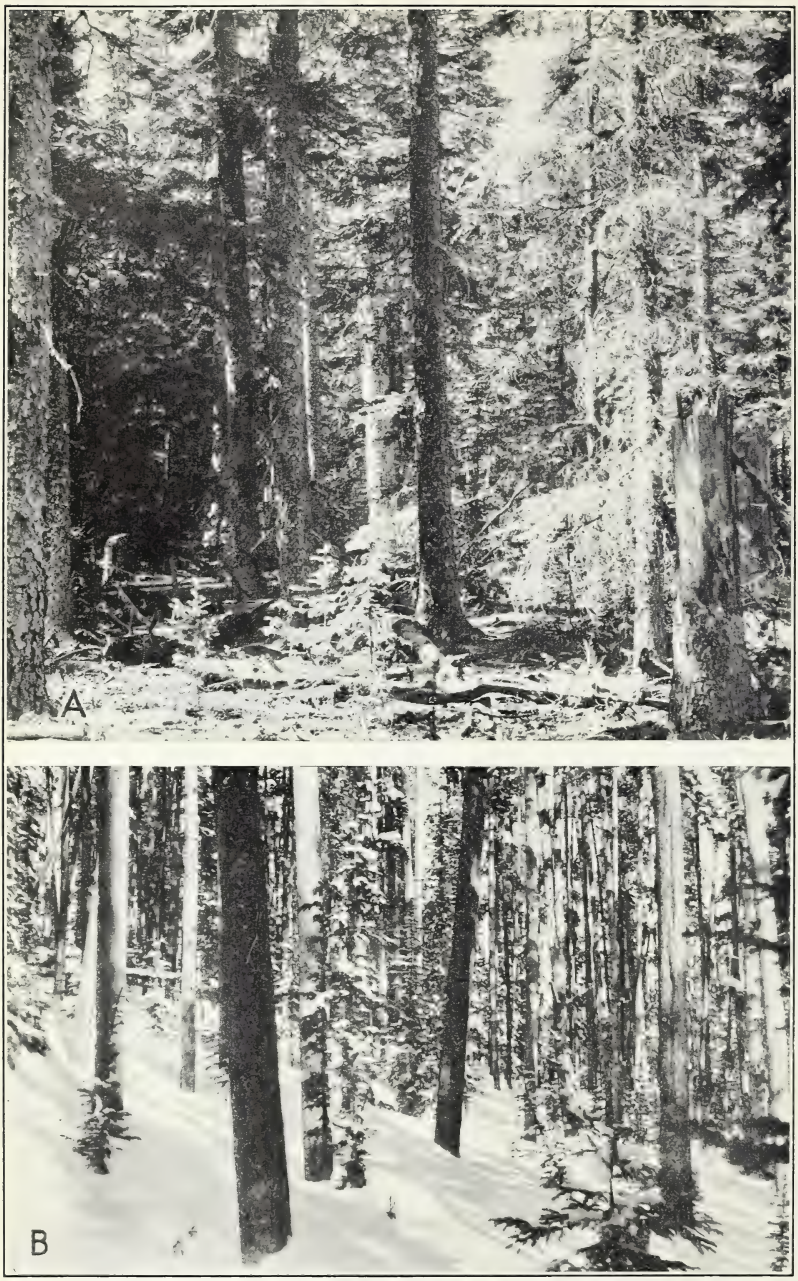
THE EFFECTS OF FIRE VARY IN DIFFERENT FOREST TYPES

A.—On a typical fire-swept area in the Engelmann spruce type no seed trees survived and reproduction is entirely lacking even after 50 years. Instead, a grass and weed cover make conditions unfavorable for restocking.

B.—On the contrary, plentiful reproduction nearly always follows the burning over of lodgepole pine forests. The burn shown was as severe as that in (A), but restocking was complete—in fact, too dense for growth to be satisfactory.



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ENGELMANN SPRUCE IS SECOND IN IMPORTANCE IN THIS REGION

A.—A typical stand of mature Engelmann spruce.
B.—Engelmann spruce reproduction in a stand of lodgepole pine, illustrating how Engelmann spruce may come in under shade on moist situations and replace lodgepole pine.

leakable ash pans, the fire danger can be greatly reduced. Speeder patrol is desirable on all roads, and on some is essential. In any event, it is a burden to be assumed by the railroad and not by the timber owner.

Since 1921, campers and smokers have been responsible for most of the fires in the forests of this region. Lightning starts a good many fires, but usually on the high, rocky ridges, where continuous bodies of timber do not occur. Throughout the southern and eastern portions of the region lightning is generally accompanied by enough precipitation to render damage from this source negligible.

At the present time there is only one private protective agency in the region. It is made up of a group of summer-home owners near Denver who have formed a cooperative organization known as the Denver Mountain Parks Improvement and Protective Association. A similar group near Colorado Springs is considering the advisability of organizing both for fire protection and to encourage better cutting practice.

Montana and Idaho are the only States having organized systems of fire protection. In addition to State land, this protection also covers private holdings not so located as to be protected by other means. In Montana men are also furnished to work with the Federal Forest Service organization under the fire-cooperative provision of the Clarke-McNary law. In addition, this State has contributed on a proportionate basis toward paying the costs of protecting the State lands that are located within or adjoining national forests. By these means satisfactory protection is established.

The Forest Service is the only other agency in the region having a fire-protection organization. But many private landowners are assisting by financial cooperation. Landowners who can not readily and economically do their own protective work deposit annually with the Government sums estimated as necessary to pay for the protection. The Northern Pacific Railroad thus provides for the protection of its holdings in Montana within or adjacent to the Absaroka, Gallatin, Beartooth, and Helena National Forests. Its deposits are made on the basis of Forest Service expenditures, the company paying its proportion of the protection costs, and, in addition, paying for fire suppression on a pro rata basis.

Every employee of the Forest Service is impressed with the fact that his first duty lies in protecting the forests from fire; during seasons of the year when fires occur prevention and suppression take precedence over every other activity. In addition, assistance is given the regular force by the employment of men who serve as lookouts and patrolmen for temporary periods when the fire danger warrants. In northern Colorado and in Wyoming, where the lodgepole pine type predominates, each ranger is responsible for fire protection on a district of about 150,000 acres, and the average yearly cost of fire protection and suppression amounts to about 1½ cents per acre. In a portion of Colorado where the Engelmann spruce type prevails, each ranger is responsible for such protection and suppression on approximately 200,000 acres, and the expense is about 1 cent per acre.

Conditions in these two localities are fairly representative of the region. In the lodgepole area 42 year-long rangers are employed, who are assisted by 4 lookouts and 6 guards for an average period of

four and one half months yearly, the protection charge including only the time actually spent in fire prevention or suppression work. This force is, however, strongly supplemented by volunteer forest wardens—responsible local residents with whom arrangements are made in advance for taking initial action in fire detection and suppression. These men, paid only when actually engaged in suppression work, are a very important factor in protection—in fact, many of them can be relied upon to take satisfactory action as promptly as regular forest officers.

Protective improvements are also necessary, including telephone lines, lookout towers, trails, and roads. The expenditure necessary for such items varies greatly throughout the region. They are in nearly every case provided by the Federal Government and are not included in the cost figures given. In addition, living quarters for the personnel are essential; also pastures to take care of stock used in protection work.

Equipment, such as instruments for lookouts, tools for fire fighting, etc., is also made available by the Government for use of the men, and in special cases light trucks are used to expedite transportation.

A small sum of money is spent each year in publicity and educational work, for prevention is the surest means of reducing fire danger, and a feeling of public responsibility does much to secure cooperation in actual suppression.

REPRODUCTION

LODGEPOLE PINE TYPE

Lodgepole pine is an excellent seed producer. Trees begin to bear cones when they reach an age of about 15 years, and they produce at least a fair crop of seed each year. Part of the cones are so persistent, remaining unopened on the trees for years after they ripen, that delayed seed germination may reasonably be counted on in all stands where the trees have reached cone-bearing size. Furthermore, the cone scales are so thick that the seeds are not readily injured by fire. Accordingly, with all these favorable circumstances and the fact that the mineral soil exposed on burned-over areas makes the best sort of seed bed, plentiful reproduction may nearly always be counted on to follow the burning over of lodgepole pine forests. (Pl. 3, B.) Mason's (*10*) examination of 181 sample plots on burned and unburned areas in Montana and Wyoming showed that approximately 70 per cent of the reproduction comes in within five years.

If, however, fires occur before trees have reached cone-bearing size, and the burn is so extensive that reseeding can not take place from the side, the land remains treeless for an indefinite period. This emphasizes the importance of protecting reproduction and sapling stands.

Logging on private lands, varying from practically a clear cutting to only a fairly heavy partial cutting, has uniformly resulted in satisfactory reproduction, provided repeated fires have not occurred. Reference to some of these old cuttings is of interest in this connection, since the results are representative of those obtaining throughout the type.

ARROW BURN—NEAR FRASER, COLO.

On an extensive lodgepole pine area adjacent to Arrow and Middle Park, where cutting took place in 1908, slash was left where it fell. Although the removal was very heavy, a few unmerchantable old trees remained, as well as a good deal of advanced young growth. Reproduction followed with a density of several thousand seedlings to the acre. After a few years a fire ran through the slash, destroying all of the forest growth. Nevertheless, sufficient seed remained as a result of delayed germination from storage in unopened cones, so that complete restocking followed, resulting in an excellent stand on all portions of the area, except where subsequent fires have destroyed it.

BIGELOW ESTATE—NEAR TOLLAND, COLO.

On about 2,000 acres cutting has occurred intermittently since about 1910, varying from selection to clear cutting, with no attention to disposal of slash. Satisfactory restocking has taken place on all lands except those most recently cut over, where sufficient time has not elapsed for reseeding.

CARBON TIMBER LANDS, SOUTHERN WYOMING

These comprise approximately 30,000 acres within the Medicine Bow National Forest. All degrees of cutting were employed, and tops were left as they fell. Satisfactory reproduction has taken place in spite of heavy sheep grazing.

Many other cutting areas and experimental plots on cut-over and burned-over areas could be cited where similar results have occurred.

ENGELMANN SPRUCE TYPE

Engelmann spruce begins to produce seed at about 25 years of age, but with no regular interval between large crops. Occurrence of killing frosts during blossom time seems to be the controlling feature. Partial shade favors natural reproduction. (Pl. 4.) Generally little difficulty is experienced in obtaining ample restocking on cut-over spruce areas, provided the cutting is not followed by fires. Fire not only destroys the sources of seed but induces a rank growth of weeds and grass, making a condition very unfavorable for reproduction. Productivity in such instances can be restored only by planting. This situation emphasizes the importance of fire protection in this type. Alpine fir seedlings often predominate even where the original stand contains only a small percentage of this species. Many of these seedlings are short lived, however, and disappear before the spruce reaches maturity.

DOUGLAS FIR TYPE

Douglas fir begins seed production when about 25 years old. In general, it is not a strong seeder, and germination is only moderately high. Investigations in the Douglas fir type in central Colorado covering a period of 14 years show that good seed years recur about every 3 years. However, 50 per cent of all the seed produced in that time was the crop of a single year.

In the Douglas fir type in the southern and eastern portions of the region satisfactory reproduction is usually obtained without difficulty on cut-over areas if fire has not occurred and if the cover and slope give the necessary protection from the direct rays of the sun. (Pl. 5, A.) In this respect the young fir seedlings are very different from those of lodgepole pine. In fact, advance growth is generally present on these areas at the time of cutting, and on many sites the stand of immature trees is so dense that it seriously interferes with subsequent development. Thus a future crop is insured, the trees of unmerchantable size—those less than 10 inches in diameter—being generally sufficiently numerous to aid greatly in reducing the period which must elapse between cuttings. This characteristic is very important wherever continuous production is attempted.

On the drier sites, particularly toward the southern limits of the region, conditions on burned-over lands are usually less favorable for reproduction of Douglas fir than for lodgepole pine and aspen. This has resulted in many areas that originally supported stands of Douglas fir going over to these other types. There are, however, some good examples of abundant reproduction of Douglas fir coming in on burned-over lands, such as the tracts on the Pike National Forest in Colorado, where Christmas-tree thinnings have been made. (Pl. 5, B.) It is probable in this instance that a good seed crop occurred the year of the fire or directly following it, and that moisture conditions were favorable for natural reproduction.

MEASURES NECESSARY TO KEEP FOREST LANDS PRODUCTIVE

Forest lands are regarded as productive when they are so managed as to produce continuous crops of timber that, at intervals consistent with the growing time required by the principal species, are worth harvesting. Facts regarding growing conditions in the lodgepole pine region have already indicated that the forests of the three main types tend to remain productive if they are protected from fire. However, even with the assistance of this great natural advantage, the mere mechanical compliance with certain prescribed measures for the protection of the timber stands is not likely to produce results that are fully successful. It is essential that operators and owners of forest property be genuinely interested in the future of the forest if stability of production is to be assured.

The measures necessary to keep forest land productive in the lodgepole pine region generally fall into three main categories—fire protection, slash disposal, and method of cutting. In the lodgepole type, no limitation on the degree of cutting is necessary to keep the land productive. In the Engelmann spruce and Douglas fir stands, advance growth, consisting of trees under 10 inches in diameter, is usually present at the time of cutting. As trees less than 10 inches in diameter are ordinarily unmarketable, other limitation than the normal market demand is rarely necessary. Very occasionally a local demand for mine props or other small material will take trees below 10 inches, or in some instances trees below this diameter will be so few as to make the operation practically a clear cutting. In these exceptional circumstances from three to five trees per acre 10 inches in diameter or larger should be left as seed trees.

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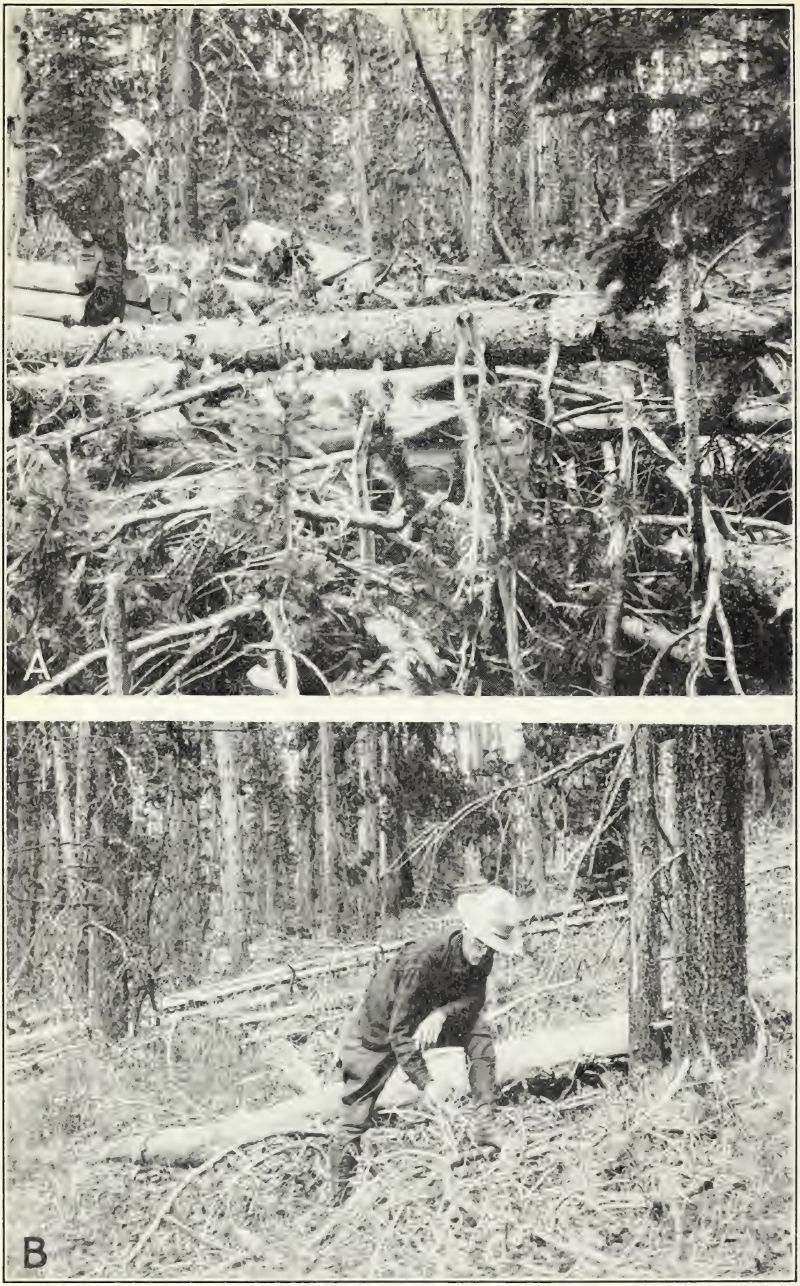
DOUGLAS FIR STANDS ARE READILY RENEWED AFTER CUTTING

The dense stand of uneven-aged advance growth (A) shows how advance growth in this type insures a future crop. Even when the cut-over area is immediately burned over abundant reproduction may follow, as in this stand (B) thinned for Christmas trees 45 years after the burn. Here presence of seed on the ground and favorable conditions immediately following the fire were apparently responsible.



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LOPPED LODGEPOLE SLASH IS NOT LONG A SERIOUS FIRE HAZARD

A.—The permanent hazard lies in the large amount of unmerchantable material left after cutting, a condition typical of many more mature stands.

B.—Even five years after lopping, when the needles have disappeared and the highly inflammable small material has been crowded close to the ground by the winter snows and is in contact with moisture, the accumulation of larger material remains. Even piling and burning would not remove this menace.

Cutting methods will be discussed in detail in the succeeding section of the bulletin under the heading "Desirable practice for obtaining fuller and more valuable timber crops." As the prime requisites for mere forest productivity, fire protection, and slash disposal are presented here.

FIRE PROTECTION

Although natural reproduction can usually be readily obtained, adequate fire protection is by far the most important measure for insuring that forest lands shall continue in a productive state. It has additional importance in view of the necessity for making certain that watersheds shall be adequately protected.

The first essential in fire suppression is that forest fires be located quickly, reached promptly, and controlled and extinguished before they spread. The earlier discussion of present protective agencies has indicated how the protective organization should function to accomplish this and in what manner it should be equipped. The goal should be an organization that will make it possible for at least one man to reach any point on the protected area, prepared to fight a fire, within the requisite number of hours after time of discovery. This requisite period may be fairly accurately defined for the different forest types and timber stands. It is termed the "hour control."

In the lodgepole pine and Douglas fir types, the objective should be a 2-hour control for mature stands and a 1-hour control for areas of special hazard such as cut-over lands where slash has been lopped, and for extensive areas of reproduction. In the Engelmann spruce type, a 4-hour control is sufficient for mature stands and a 2-hour control in localities of special hazard.

These objectives require an organization of the size already described as effective on the national forests; namely, an average of about 1 man for each 150,000 acres in the lodgepole pine and Douglas fir types and 1 man for each 200,000 acres in Engelmann spruce. This force is exclusive of lookout men and temporary assistants. Except for the special improvements necessary, such as roads, trails, telephone lines, lookout towers, and cabins, which vary greatly in different localities, this protection should cost, as already stated, about 1.5 cents per acre for the pine and fir types and about 1 cent per acre for spruce.

Other measures affect directly the individual forest users and residents and depend for their success entirely on the degree of interest and cooperation that these persons contribute.

Oil should be used for fuel in locomotives traversing timbered areas, but where this is impracticable nonleaking ash pans should be provided and carefully maintained. Even with this precaution, rights of way should be kept cleared of inflammable material for a distance of from 50 to 100 feet on each side of the track, the width of clearing depending upon local conditions. In addition, speeder patrol should be maintained.

All wood, oil, or coal consuming engines operated on or adjacent to forest lands during the fire season (usually from about June 1 to October 15) should be provided with efficient spark arresters.

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During periods of extreme fire hazard, prohibition of smoking in the timber may be warranted. Suspension of operations may be desirable but is not likely to be necessary except in the rare cases where railroad logging may be employed.

All logging camps and sawmills on forest lands, or so located as to endanger them, should be provided with satisfactory fire-suppression tools and equipment, and suitable clearings should be made to prevent the spread of fire to adjacent timber. On the larger operations, tool caches should be located at strategic points throughout the woods. Sawmills should always be provided with adequate spark arresters and with safe refuse burners. At mills large enough to justify such measures, power pumps and night watchmen should also be provided. In small operations, sawdust need not be burned but should be piled separately from other refuse.

A check should be kept to see that roof jacks are properly installed in camp buildings and that ceilings and partitions are properly protected from stovepipes. Stoves should be placed at a safe distance from walls and be set high enough to allow air spaces beneath them.

In addition, a fire plan should be in effect providing for a code of emergency signals from the mill, the assignment of all employees to specific jobs in case of fire, and the listing of available equipment, supplies, and outside help. Such a plan may vary in form, according to the size of the operation and fire hazard, from a mere verbal understanding among the men employed to a written plan.

Individual timbered units in private and State ownership are usually not sufficiently extensive or consolidated at this time to warrant the building up of independent fire protective organizations. Accordingly, it is suggested that protection of such lands be attained through yearly assessments for a common fund equal to the cost of protection. Such a fund might be expended by the United States Forest Service, by the State, or by private fire-protection associations, depending upon which agency has a satisfactory organization responsible for fire protection in the locality or is otherwise the logical agency to take the leadership.

Residents on or adjacent to their timberland who, by reason of their location, can give adequate protection should be exempt from such assessments. Cooperation by local residents has been found to be a very important factor in fire protection. In working out any fire-protection plans, particular attention should be given to arrangements for cooperation in fire prevention and suppression between timber operators and their employees, graziers, and other forest users, and in fact all local residents.

SLASH DISPOSAL

Since earliest times, slash resulting from timber operations on private and State lands has generally been left where it fell, and at first, with public sentiment apathetic and no organization to take the lead in fire prevention or suppression, this resulted in many extensive burns and much serious damage. After the national forests came into being, most privately owned timber became intermingled with or adjacent to lands for which a systematic plan of fire protection was

developed. This situation gradually brought about a sentiment strongly in favor of protection. At present the damage from forest fires starting on privately owned land is no longer serious during normal years. However, during years of unusual fire danger, operations on private lands may become a serious menace to adjacent publicly owned timberlands.

Of late, State laws have brought about improvement in slash disposal. In Montana slash has been burned broadcast, largely in compliance with the State law. A recent revision of this law provides for piling and burning débris resulting from clearing rights of way, and for disposal of slash resulting from logging operations in the manner prescribed by the State forester, subject to a maximum expenditure of 15 cents per thousand feet of timber cut. In Idaho in 1925 a law was passed requiring that all slash resulting from timber cutting be piled and burned, except where the State forester approves the application of some other method. Other improvements in method have occurred on State lands in Colorado and Wyoming, where the slash-disposal methods employed on national forests have been followed.

The effects of these different methods of slash disposal vary in the lodgepole pine and Engelmann spruce types. In the lodgepole pine type broadcast burning of slash results in too dense reproduction, as may be seen by examining cut-over areas over which fire has run for the first time. Burning the slash in piles, or "piling and burning," as it is termed, a practice which has been followed extensively on national-forest cuttings in this type, does not ordinarily result in so much reproduction as to be detrimental, but it is clear that the expense of this practice is warranted only where it is necessary for fire protection. (Pl. 6.) Furthermore, studies made on cut-over areas show that even where piling and burning are carefully done, large standing trees suffer appreciable damage through the scorching of their trunks and the killing of roots located under the slash piles. Also some small trees are killed outright. Scorched trees grow much more slowly than those which are uninjured, and fire scars are also entrance points for rots.

On the other hand, wherever in the lodgepole type slash may be left on the ground without constituting too great a fire hazard, it is important as an aid in building up the productivity of the soil, and in many places it aids materially in preventing erosion. Nor will tops left in place nor limbs lopped and left obstruct appreciably a sufficient growth of seedlings—as studies (*3*) on the Medicine Bow National Forest in Wyoming and on the Gunnison National Forest in Colorado have demonstrated. In fact, less-crowded reproduction usually results where slash is not piled and burned. The needles drop off the lopped limbs in about two years, and the lighter portions of the slash disintegrate materially in from three to five years, thus removing within a comparatively short period an important part of the fire risk.

This is well illustrated by conditions on the Wyoming Tie & Timber Co. operation on the Washakie National Forest in northern Wyoming, where this plan has been followed with satisfactory results since the summer of 1916 in connection with an annual cut of about 12,000,000 board feet; also near Pitkin, on the Gunnison National

Forest in Colorado, where cutting took place about 1918. On the former area slash was close to the ground after about three years and was no longer a serious fire menace. On the latter area, where the timber was utilized to a 4-inch top diameter, it was hardly evident 10 years later that any slash had been left. Fire hazard on such areas will probably be greater than in the uncut stands for a number of years, but whether the expenditure, which averages $10 an acre for piling and burning all slash, is warranted, depends on the degree of fire danger, and this is light in much of the lodgepole region.

Piling and burning slash in all places of special fire hazard, such as around sawmills and camps and along main roads (not exceeding 5 to 10 per cent of the entire cutting area), and lopping elsewhere has since 1922 been the plan followed on practically all national-forest cuttings in Colorado and east of the Continental Divide in Wyoming, including the large operation in Wyoming mentioned above. No increase in the acreage burned annually has resulted in these forests, even in dry summer seasons—1924 being the driest since 1888. So far no additional fire-protective force has been employed, though this may be warranted during seasons of extreme hazard. Should a special patrol become necessary, the maximum expenditure on this account would not anywhere nearly equal the cost of piling and burning all slash. It is essential, though, that areas of special hazard, such as those mentioned, be cleaned up by piling and burning if adequate protection is to be assured. (Pl. 7, A.)

In most cutting operations on national-forest lands in the lodgepole type in the northern and western portions of the region, all slash was piled and burned prior to 1928. However, beginning with that year, the policy outlined above was adopted in those localities, except that in the northern and western portions of the region, as a modification of this practice, tops not piled and burned are left unlopped.

In the Engelmann spruce type more slash and débris are usually left after logging than are left in lodgepole pine. This is because the spruce has more and larger limbs and utilization is generally not so complete. However, spruce needles drop off during the first year after cutting, unlike the lodgepole needles, which may persist for two years or longer. This characteristic is an important reason why spruce slash does not ordinarily need to be piled and burned, except on specially hazardous areas. The moist sites and short danger season are also important in this respect. Accordingly, on the national forests throughout the greater portion of the region (pl. 7, B) the spruce limbs are lopped and left, except on areas of special hazard, where they are piled and burned as in the lodgepole pine type. However, in the national forests of the northern and western portions of the region, where conditions are more dangerous, all slash is piled and burned.

Results from lopping slash are different from those obtained by merely leaving the tops where they fall, the practice followed on private lands. Snow soon crowds the lopped slash close to the ground in contact with moisture, instead of leaving it up off the ground subject to rapid drying out. Unlopped tops not only make hotter fires but seriously interfere with travel and so may retard suppression.

Disposal of slash in the Engelmann spruce type is primarily a protection measure and has comparatively little bearing on silvicultural results. Piling and burning slash, as already noted with regard to the lodgepole type, is likely to result in damage to standing trees and to lower the productiveness of the soil. With the relatively low hazard in the Engelmann spruce type as a whole and the regional fire-protection system, the expense of piling and burning slash is warranted only on areas of special hazard and where the type dries out to an unusual degree, as in the western and northern forests.

Slash disposal for the three main types may be briefly particularized as follows:

LODGEPOLE PINE AND DOUGLAS FIR TYPES

Pile and burn slash 4 inches in diameter and smaller resulting from cutting operations, as follows:

Along railroad rights of way where fuel oil is not used for a distance of 100 feet on each side of the right of way.
For a distance of at least 100 feet around camps.
For a distance of 100 feet on each side of main logging roads or highways.
For a distance of 50 feet on each side of trails.
In localities of high risk, on enough strips 100 feet wide, in addition to the above, and taking advantage of all natural fire lines, to leave no continuous areas of slash exceeding 160 acres.

Elsewhere tops of trees may be left where they fall, except where the danger of fires starting is serious. In such instances limbs should be lopped from tops and conditions made favorable for the slash to disintegrate as fast as possible. This means that slash should be piled and burned on about 5 to 10 per cent of the cutting areas and in other places lopped or left in place.

Wherever in Idaho and Montana this plan of slash disposal is insufficient to render adequate protection the piling and burning of all slash may be warranted.

On steep slopes where the ground is naturally bare and subject to erosion slash should not be burned but placed in skid trails, roads, or gullies.

ENGELMANN SPRUCE TYPE

Tops of trees may be left where they fall in places where the danger of fires starting is not serious, but where fire danger is great and it is important that conditions be made favorable for slash to disintegrate as rapidly as possible limbs should be lopped from the tops.

Additional precautions may be necessary in specially hazardous localities, such as certain areas in the northern portion of the region, where a combination of lopping and piling and burning, as outlined for the lodgepole pine type, may be warranted, or even the piling and burning of all slash.

Where slash is to be burned, the piles should be compact and tepee-shaped so that they will burn satisfactorily under snow. An ideal pile is one about 5 feet high and 5 feet in diameter at the base, with small material at the bottom and large limbs placed butt upward toward the center, so that the larger portions will fall into the middle of the fire and burn completely. Piles should be located at a

sufficient distance from standing green trees so that they may be burned with no damage, or with a minimum damage to the remaining stand as well as to reproduction. Slash disposal should be completed as soon as practicable after cutting takes place, and within a maximum period of one year. (Pl. 7, A.)

COST SUMMARY

The expense in the lodgepole and fir types of lopping tops, combined with piling and burning the slash on 5 to 10 per cent of the total area, amounts to 30 to 40 cents a thousand board feet, or about $3 to $6 an acre. Piling and burning all slash costs about 80 cents to $1 a thousand feet, or about $6 to $14 an acre, averaging about $10. In the Engelmann spruce type the cost of lopping tops amounts to 15 to 25 cents a thousand board feet, or about $2 to $5 an acre, for the average stand. These estimates are based upon the expenditures which a large number of operators throughout the region are making in carrying out such measures.

The total cost of the measures necessary to keep forest lands productive may be summarized as shown in Table 1.

TABLE 1.—*Summary of cost of measures necessary to keep forest lands productive*

Measures recommended	Cost per M feet	Cost per acre
FIRE PROTECTION	*Cents*	*Cents*
Lodgepole and Douglas fir types		1.5
Engelmann spruce type		1.0
SLASH DISPOSAL [1]		*Dollars*
Lopping	15–25	2–5
Lopping with piling and burning on strips making up from 5–10 per cent of area	30–40	3–6
Piling and burning all slash	80–100	[2] 6–14

[1] Based on $4 daily wage and an average stand of 10–15 M board feet per acre.
[2] Average about $10.

PREFERRED PRACTICE FOR OBTAINING FULLER AND MORE VALUABLE TIMBER CROPS

The effort has been made in the preceding section to outline measures, mainly protective, that would suffice to keep the forest lands of the lodgepole pine region in a productive condition, supporting marketable crops of pine, spruce, and fir timber. These measures may in many instances amount to forest practice as intensive as is possible under existing economic conditions, since natural reproduction is obtained with such readiness that no special attention need be given this feature, and since the slow growth of the principal species can not even by the most intensive practice be brought up to that obtainable in many other regions. Where additional measures are needed in order to produce fuller and more valuable timber crops, these will take the form of refinements in cutting practice or, better, a closer adaptation of the current practice to the variation in condition of stand and forest type that is so frequent and abrupt throughout the region.

If it be argued that returns from the forest lands in this region are at present so meager as to make it impossible for private owners to undertake any but the simplest protective measures for their timberlands, the answer must be that the measures suggested in the following pages have been worked out mainly with the idea of present application only where conditions are especially favorable, but at the same time with the idea in mind that their usefulness will increase and widen constantly as economic causes increase the demand and improve the market for local timber. The measures recommended are by no means fanciful or purely theoretical. They agree closely with the practice now followed on the national forests, a practice based on a long period of observation and research. For any timberland owner who, like the United States Government, can afford to invest liberally in the production of stands of high quality destined eventually to bring a full return, the measures proposed here are essentially practical, as has even at this time been thoroughly demonstrated.

METHODS OF CUTTING

PRESENT CUTTING PRACTICE ON STATE AND PRIVATE LANDS

In Colorado, contracts for the sale of State timber provide for cutting no trees under 10 inches at breast height, but the State has lacked an organization by which a close check might be kept on actual cutting operations to see that smaller trees are not taken. In view of the land exchange with the Federal Government which this State has planned, cutting on State lands has been rather limited for the past several years. If the exchange becomes a reality, arrangements will undoubtedly be made for an effective administration of the new forest and for better sales practice.

The accessible private lands in Colorado have been, or are being, heavily cut over and, as in private-land enterprises in all of these States, all marketable material is removed in the initial operations, which are generally followed by further cuttings whenever markets warrant. This means that as a general practice recuts are made on most of the more accessible areas whenever any material is of mine-prop size. A ranch firm in eastern Colorado, for example, recently sold every stick of timber on its lands for a flat sum; this resulted in the operator cutting thrifty young trees containing only one railroad tie to a tree and leaving half or more of the volume as waste.

Outside of Colorado comparatively little timber is cut on State lands. In Wyoming the only recent cutting on State lands has been within the Medicine Bow National Forest, where the Forest Service has cooperated in administering the operations. Within the region covered by this bulletin, practically no timber is being cut on State lands in Idaho, Utah, and Nevada, and only a very small quantity in Montana.

On private lands in Idaho, Nevada, Utah, and Wyoming the condition is much the same. In Montana many of the more accessible private lands were heavily cut in the early nineties, and comparatively little cutting is now taking place on the more inaccessible areas.

In the lodgepole type the characteristic small size and the crowded habit of growth restrict the commercial use of the species mainly to

hewed railroad ties, mine timbers, and mine props. The making of hewed railroad ties on an extensive scale, however, usually produces as a by-product a supply of mine-prop material (pl. 2) entirely out of proportion to the quantity the market can absorb, so that even on areas privately owned lodgepole is seldom cut clear. Very much the same condition obtains in the Douglas fir type.

Cut-over areas in the lodgepole type are usually left in a nonuniform condition. Tie-size trees are seldom to be found; on some areas the small, prop-size material has been cut and the saw timber left, and on others saw timber has been taken and the smaller trees have been left; on a very few areas only has all material down to mine-prop size (4 inches in diameter) been removed. In addition to trees of poor form and defective trees on lodgepole and Douglas fir cuttings, a quantity of reproduction, saplings, and small poles almost invariably remains, assuring at least a scattered stand for the production of seed, and young growth sufficient to provide future cuts.

In the Engelmann spruce type the fact that there is usually no market for trees less than 10 inches in diameter at breast height gives assurance ordinarily that sufficient immature trees will remain after cutting to maintain productivity. However, on rather restricted areas where stands are made up almost wholly of large trees, an insufficient number of smaller ones may remain to insure perpetuation of the forest. In such places it is important that a partial cover be retained to furnish seed and provide shade for reproduction, even though the trees left may be of merchantable size and not capable of increased growth. Since Engelmann spruce is naturally subject to wind throw, careful attention must be given to selecting the shorter, windfirm specimens for this purpose.

CHIEF CONSIDERATIONS GOVERNING CUTTING

CUTTING AT MATURITY

In general, trees should be cut as nearly as possible at the time when the mean annual growth (or the quotient of the volume of the tree divided by its age) begins to decline. This, of course, does not coincide with the time of greatest diameter growth, since on a tree of large circumference the later, narrower growth rings may indicate a greater volume growth than do the wider rings near the center. The criterion is volume growth, not diameter growth. When growth ceases to increase satisfactorily, the tree should ordinarily be harvested. It is at this point considered to be mature.

Table 2, prepared by C. G. Bates, from local volume tables for Engelmann spruce, is generally applicable for the region, and illustrates this point. It will be helpful in determining the maturity of any tree.

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TWO FORMS OF SLASH DISPOSAL

A.—The lodgepole pine slash is well piled and is ready for burning when a snow cover makes it safe.

B.—In the Engelmann spruce type the slash left on the ground is after two years less dangerous than at first. Needles drop off during the first year after cutting.

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A CUTTING IN AN IDEAL THRIFTY LODGEPOLE PINE STAND

An application of the partial cutting system has resulted in a stand of seedlings, saplings, and poles that will form the basis of future cuts and yield maximum returns for the site.

TABLE 2.—*Table of volume growth for Engelmann spruce*

Diameter, breast high, inches	Rings per outside inch of radius required to produce increment equal to—		Diameter, breast high, inches	Rings per outside inch of radius required to produce increment equal to—	
	5 board feet per year	1 cubic foot per year		5 board feet per year	1 cubic foot per year
	Number	*Number*		*Number*	*Number*
6			20	20	17
8		3	22	24	19
10	4	6	24	27	21
12	7	10	26	30	23
14	11	13	28	33	25
16	14	15	30	36	28
18	17	16	32	40	30

Table 2 brings out the importance of studying carefully the individual tree before deciding which tree it is desirable to retain in the stand. It shows the number of annual rings to an outside inch of diameter required to maintain a uniform increment. In order to determine for any species whether a tree of a given diameter is still maintaining a uniform rate of increment, it will merely be necessary to see whether the ratio of the number of rings in the outside inch to the number in the preceding inch is approximately the same as that of corresponding counts shown in Table 2. Board-foot volume is usually the more important indicator of the value of each tree. Table 2 shows that in cubic feet (applicable for pulpwood) trees are putting on relatively less volume in the larger sizes. This emphasizes the fact that the actual cubic-foot volume of trees does not increase so rapidly with size as board-foot volume does.

In so large a region, with such greatly varying conditions, it is impossible to prescribe a method of selecting mature trees that is universally applicable. Each stand of timber is a problem in itself and requires special consideration and skill on the part of the person selecting trees for cutting. If the desired results are to be obtained, each tree must be examined closely, and conclusions based on external appearances must be checked by an examination of annual growth rings sufficient to insure the proper basis for selection. The last few rings may be examined without serious damage by chipping the tree, or an increment borer may be used to advantage.

DEGREE OF CUTTING

Methods of cutting and degree of cutting are of extreme importance in their effect upon satisfactory growth and a stabilized output. Except where stands are overmature, very heavy cutting or clear cutting results in loss of increment during the period of reproduction and makes sustained production from a given management unit more difficult. Furthermore, such practice, even though it may be warranted by the condition of the stand, can be followed only where market conditions are very favorable. A larger proportion of desirable and valuable products are obtained from the larger trees. This is an important consideration in view of the pre-

ponderance of small trees in the region and the fact that the general market situation is entirely inadequate to use more than a portion of the small material that can be produced. Accordingly, broadly speaking, heavy cutting is not desirable save where markets have made it possible to utilize completely the small material in the tops of the trees cut primarily for larger products.

As a matter of fact, cuttings as light as the condition of the stand and the market situation permit are most desirable from the standpoint of growth, since they aid in complete utilization of trees cut and contribute also toward uniform or sustained production. Light cuts at relatively short intervals make it possible to maintain a growing stock of trees which will take full advantage of the productive capacity of the soil. Furthermore, trees which die or blow down are likely to be totally lost through decay if the harvests occur at intervals of 30 to 40 years, whereas frequent light cuts insure close utilization of such material.

It is extremely important in cutting timber in any type that the cutting practice change as differences in the stand warrant. In passing from a thrifty to a decadent stand the cutting practice should be changed abruptly. Also the open character of a stand may have a very direct effect upon the degree of cutting; isolated trees or groups of trees in openings should be left, or cutting should be very conservative, for trees in such locations aid materially in seeding up these openings. This also applies to trees on the upper slopes or on the crests of ridges, which may be ready for cutting but by reason of their commanding position are in many cases valuable as seed distributors. Dense stands of lodgepole of rather uniform character, which are located on exposed ridges or extensive unprotected tablelands, are subject to damage from windthrow, particularly when openings are made by cutting operations, and this is another feature requiring careful consideration in regulating cutting.

The degree of maturity of the individual tree is often the controlling factor in deciding whether defects or diseases are of sufficient importance to warrant removal. It is often desirable to retain thrifty trees that have sufficient space for further development regardless of small dead tops or small cankerous growths. On the other hand, trees approaching maturity and containing similar defects should usually be cut. This is particularly true where satisfactory younger trees are available.

PROTECTION OF YOUNG GROWTH

A very important consideration in any system of cutting is the preservation of immature trees while cutting is in progress. Studies show that tremendous losses occur when this is neglected. Much of this damage can not be avoided, as on areas cleared for roads, skidways, and camps, or other improvements. There is, however, a general lack of appreciation on the part of cutters and other woods workers of the value of young trees. If this were confined to inferior species, it would not be so serious, but detailed studies along this line show that unnecessary damage occurs to the valuable species in the same proportion as to those which are inferior. Needless destruction of immature trees has a very important effect upon the stand remaining to form the basis for future cuts. It reduces the

volume which will be available for cutting, and may actually mean a longer period before the next harvest will be practicable. This situation is of extreme importance, and is prevalent in other regions as well. The need for preserving young trees must be "sold" to woods workers if this situation is to be remedied.

CUTTING MEASURES RECOMMENDED

IN POLE STANDS

Pole stands occur rather sparsely in the Engelmann spruce and Douglas fir types. Cutting in these stands is limited because of insufficient markets for small material. However, as a general rule this class of stand is not so urgently in need of thinning as in the lodgepole type, although it would be desirable to remove inferior species, such as alpine fir, and also seriously defective and diseased trees.

Pole stands of lodgepole pine occur extensively. They are of two distinct sorts, the immature, thrifty stand and the stunted stand of overmature trees. Whether a selection system of cutting or clear cutting should be followed depends upon the character and condition of the stand as well as the availability of markets for small material.

Mature and overmature pole stands are made up of trees varying from 4 inches in diameter breast high and smaller to trees of saw-log size. These have resulted from overcrowding on sites adapted to the production of saw logs or railroad ties, or from the incapacity of the site to grow large material. Generally, market limitations do not permit much cutting in stands of this character. Where possible, however, all mature trees should be cut, only thrifty, immature trees safe from wind throw being reserved. Care should be taken to retain any thrifty, windfirm Engelmann spruce and Douglas fir on sites suitable for growing these more valuable species.

Immature pole stands of lodgepole are made up of trees of sizes similar to those in the mature stands, but having the capacity of putting on increased growth if a thinning is made. The thinning should remove the defective, diseased, and poorly formed trees as well as those which have been affected most by the crowding. It should leave a sufficient number of the better trees in a position and condition to produce a maximum amount and quality of wood, and for this reason the removal of trees should be undertaken with care; future production is dependent upon the number and character of trees selected to form the basis of the next cut.

Where several trees grow in a group too dense to permit satisfactory development, it is desirable to make a thinning if the trees retained will profit by the removal of others. Where certain individuals have become dominant in a group and are making valuable and rapid growth, they should be saved at the expense of suppressed and doubtful ones. Also the more valuable species should be favored; inferior species should be cut heavily. The trees left should be evenly spaced so as to provide room for development.

Pole stands averaging 8 inches diameter breast high should be so thinned as to leave about 300 to 400 trees to the acre—the number varying with site conditions and the practicability of frequent cuts. Sapling stands averaging 4 or 5 inches diameter breast high should similarly be so thinned as to leave 500 to 600 trees to the acre.

On the better soils stands up to 200 years old have shown good response to thinning. On the poor soils, response to thinning may be very slow or negligible.

IN SAW-LOG OR TIE STANDS

In the saw-log or tie stands containing trees the majority of which are full crowned and thrifty, clear cutting will probably never be justified. A selective cutting is needed in all types. In these stands sizes range from seedlings to large trees 30 inches in diameter in the spruce type, or 36 inches or larger in the fir type. The objective should be to remove all trees that have reached or passed maturity; as well as those that are defective, diseased, or suppressed, and also trees of inferior species. Cutting should be based on maturity of the tree; size is not a reliable indicator of condition. For example, Douglas fir in southern Idaho 20 inches in diameter is often immature, whereas in dense stands on poorer rocky sites in Colorado mature trees may be no more than 4 inches in diameter.

Since a good growing stock is necessary if future yields are to be as large as possible, cuttings should always be conservative. The ratio of the most desirable amount to cut as compared to the whole volume of the stand varies with the different types.

Lodgepole pine type.—In stands of this type which are thrifty or even in those which are approaching maturity it would be desirable to remove about 30 or 40 per cent of the volume of trees 10 inches in diameter and larger, and to make additional cuttings about every 20 to 30 years. (Pl. 8.) However, the condition of the stand will often be such as to call for the removal of 60 to 70 per cent of the volume. This will means greater intervals between cuts.

These stands that have grown up under crowded conditions may be subject to damage from wind throw after partial cutting. This feature must be considered, particularly on exposed ridges or on unprotected flats. On account of wind-throw danger, it may often be necessary to leave mature trees which are in a sufficiently thrifty condition to continue to grow, even though at a relatively slow rate, until the next cut.

Thinnings in these thrifty, mature stands should be made in the same manner as in pole stands. The immature trees removed should be only those containing spike tops, basal fire scars, dying or poorly formed crowns, frost or lightning cracks, insect infestation, canker infections, serious scarring by porcupines, or other defects which are so serious as to make it probable that these trees will be less valuable at the time of the next cutting.

On the soils best adapted for lodgepole pine a growth of from 100 to 200 board feet annually per acre can be expected. If markets for small products were at all sufficient to utilize the quantity of this material that can be grown, much more could be done in the way of thinning and improvement cutting. This would mean a much closer utilization of the growth than at present and the salvage of much that is now being lost because of nonuse.

In overmature stands of lodgepole pine, where the majority of trees have passed maturity and are overripe—as evidenced by sparse, short crowns or spike tops, smooth gray and thin bark, and a general

appearance of being in poor growing condition—all mature, overmature, and seriously defective trees of marketable size should be cut, even though this may result in practically a clear cut. Thrifty immature trees which are windfirm should be left to grow and to insure reproduction in case the young growth should subsequently be destroyed by fire.

Engelmann spruce type.—Because of the all-sized stands characteristic of the type, Engelmann spruce is naturally adapted to partial or selective cutting. There should be no hesitancy in immature stands of Engelmann spruce in leaving thrifty trees, at least up to 20 inches in diameter. It is desirable in this type, as in lodgepole pine, to retain a good growing stock after cutting if the full capacity of the soil is to be realized. The trees remaining should be well spaced and, under ideal conditions, should constitute about 60 per cent of the original volume contained in trees 10 inches diameter breast high and larger.

If this plan is followed, a sufficiently dense stand of young and middle-aged trees will usually remain after cutting to protect itself against wind throw, which appears to be controllable only by maintaining high density. Tall trees, the crowns of which extend much above the general height of the larger trees remaining after cutting, and which afford no protection to others and are the ones most likely to be wind thrown, should ordinarily be removed.

Annual growth will vary from 100 to 250 board feet to the acre, and on the better soils a second cut should be possible in 30 to 50 years. If the growing stock is seriously depleted through heavy and destructive cutting of young trees, it may require a long period for the stand to recover sufficiently to make a growth which even approaches this, and the period between cuts will be greatly increased.

In overmature spruce stands made up of large trees which have passed maturity (though usually they contain an understory of immature trees and reproduction) all mature and overmature trees, as well as those immature trees that are seriously defective, diseased, or nonwindfirm, should be removed. Inferior species should be cut heavily to favor the more valuable ones. Under the conditions that usually prevail, this means the removal of practically all saw-log timber and the leaving of such thrifty immature trees as are windfirm to put on valuable growth and serve in seed distribution.

Additional cuts in overmature stands will ordinarily not be possible for 100 years or more, depending upon market conditions and the time when the young trees approach maturity. The growth will be much less than in immature stands, for the growing stock will ordinarily be deficient for many years. However, heavy cutting is the only feasible way by which such stands can be converted into a productive forest.

Douglas fir type.—A selective system of cutting, as already noted, should work out particularly well in the Douglas fir type. Usually from 60 to 70 per cent of the volume in trees 10 inches in diameter and larger should be removed, which will ordinarily make possible a second cut in from 30 to 50 years. Growth will vary greatly on account of soil differences and variations in stands left after cutting, possibly from 50 to 200 board feet per acre per annum.

On the limited areas where cutting all mature and defective trees leaves a stand consisting only of seedlings or saplings, special provision must be made for seed trees. These are needed to provide for complete stocking and to insure against total loss of productivity through fire. An average of at least two, and preferably four to six well-spaced trees, of seed-bearing size, to the acre should be left. Trees with spike tops or other defects may serve if absolutely necessary, but usually sound trees will be available. Particular attention should be given to leaving seed trees along the edges of openings and on ridges.

MINOR MEASURES

Sanitation and insect control.—Mistletoe is a parasitic plant which draws its sustenance from the soft inner bark of several species of trees and results in abnormal form, slackened growth, and gradual death of the tree. In this region damage from this source is generally most severe to lodgepole pine and western yellow pine, although Douglas fir is the hardest hit of any species in the western portion. Heavily infected trees are characterized by a general appearance of unthriftiness; poor, thin crowns; sickly, pale-colored, and often short needles; distorted branches, many dead or dying; and the presence of "witches' brooms." Infected trees, as far as practicable, should be cut; but where soil conditions are poor it may never be possible to eradicate this parasite entirely.

Lodgepole pine is subject to canker infections which cause rot and often result in breakage at the point of infection. Trees with large cankers and trees rendered unmerchantable on account of rot should be cut to prevent the spread of the disease to other green trees. Those with smaller infections in a dormant condition and not seriously weakening the tree should be cut only when this can be done with benefit to surrounding trees.

The number of trees cut for sanitation does not exceed an average of 2 or 3 per acre, save in some overmature stands in the lodgepole pine type, where as many as 15 unmerchantable diseased trees may be found on an acre. The expense of cutting such trees of saw-log size usually averages about 25 cents each. Charged against the merchantable cut, this usually does not exceed 10 cents a thousand board feet, or in extremely overmature stands 35 to 40 cents a thousand. This does not take into consideration the stumpage value of the sound portions of the trees, and which may equal or even exceed the actual cost of cutting.

Invariably some damage occurs throughout the forest as a result of insect infestations of a normal character. It would be difficult if not entirely impractical to attempt to eliminate all losses from this source, but such infestations should be observed and control measures undertaken at the proper time so as to avoid the development of serious epidemics. Even though enormous damage results at the time, such infestations eventually come to an end through the work of natural parasites. Reproduction will come in again, but the annual yield will be seriously reduced for many years.

The most serious epidemic thus far is the bark-beetle attack which is now in progress in the lodgepole pine type in Montana. An epidemic of spruce budworm in progress for several years in the Douglas fir type in the Shoshone National Forest in northwestern

Wyoming has seriously damaged excellent stands of timber, but so far no methods of control have been worked out that are applicable to forest conditions.

Control work should ordinarily be undertaken before insect attacks reach the epidemic stage. In bark-beetle attacks, the infested trees should be cut in the spring or early summer before the emergence of the beetles. Either the bark should be peeled from the trunk of the tree and from the stump, or, if there is no danger of the fire escaping, the infested lengths can be decked and burned. For some species it is essential that the bark be burned; for others, the peeling of the bark is all that is required, with disposal of slash in the manner necessary for fire protection. If there is any question regarding control measures for any tree insect, the advice of the Bureau of Entomology of the United States Department of Agriculture should be obtained.

Cutting forked and leaning trees.—A tree should not be cut merely because of a fork or a slight lean. However, if the fork is so located as to prevent any appreciable increase in market value the tree should ordinarily be cut. Forks of certain types can be counted upon to split off in the course of time or to afford a point of entrance for disease. Knowledge of local timber will make possible the recognition of these types and the removal of them.

A leaning tree need not be cut unless it threatens to fall before the next cut or is likely to rub against or interfere with the development of a more valuable tree. It should, however, be taken if its lean amounts to distortion and precludes any further growth of value.

MANAGEMENT PLANS

The relatively small portion of the timbered area of this region in private ownership—mostly small holdings—makes sustained yield, or a continuous cropping of timber, possible only on some of the larger blocks of private land and on a few smaller areas so accessible to markets that they can be managed intensively like farm wood lots. However, where such areas exist they should be handled in accordance with a definite plan. Where the size and use of a block of timber warrants, this plan should include an inventory of the forest resources and a definite program of action providing for protection and for harvesting crops on a sustained yield basis.

The economic advantage of stabilized production on all areas adapted to such management is generally recognized, and need not be mentioned here in detail. Stabilized and perpetual output means permanent industries with all of the benefits to be derived from them. It makes possible lighter cuts per acre, more frequent harvests, closer utilization of material that would be wasted if cutting were less frequent, and in general much more intensive forest practice than would otherwise be possible.

The large acreage of the national forests is being managed on this basis, management plans being perfected for the various units as fast as present or prospective demands for the timber warrant. Private timberland owners may obtain assistance in the preparation of plans adapted to their needs and conditions, and assistance in working out a detailed cutting practice for specific areas, through the respective State foresters and forestry departments, as well as from State and private forest schools, wherever these are established.

IMPROVED FOREST TAXATION

The question of the taxation of forest land has never become acute in the lodgepole region, owing to the limited interest among private owners thus far in intensive forest management. There is little doubt, however, that as interest in a systematic handling of forest lands increases the demand will make itself felt for tax laws that will be mutually beneficial to the forest-land owner and the community.

Here, as elsewhere, it will doubtless be found that, even when forest tax laws are not immediately burdensome, they will be indirectly so as long as there is any uncertainty as to their consistent application. To be really effective, tax laws must promise some security for the future. They must be on a state-wide basis and applicable unreservedly to all timberland. The owner properly should have no choice as to whether his property will come under the terms of the laws, for any such optional feature very largely defeats the purpose of the legislation. Tax laws must be basically sound and yet must be so framed as to be easily understood and readily applied by local assessors. Their immediate effect must not be to decrease materially the local revenues, nor must they shift to other property the forest-land owner's just proportion of the tax levy.

These considerations raise knotty questions that remain as yet unanswered. At present extensive forest-taxation studies are being undertaken by the Forest Service under the authorization of the Clarke-McNary law. These may develop some simple, workable, and fair methods of timber taxation.

STATE ACTIVITIES

State laws should provide for the protection and administration of State forest lands and also for the protection of forest land in private ownership during periods of fire danger. They should cover all precautions necessary to keep forest lands continuously productive. The responsibility of owners of forest land for complying with reasonable requirements, dealing with precautions against forest fires and disposal of slashings on specially hazardous areas, should be clearly defined.

States should have authority and funds for cooperating with the Federal Government in growing small trees for planting wood lots, shelter belts, etc., and the distribution of such planting stock to landowners at low costs under the Clarke-McNary law. Many States, including a number of those in this region, are now distributing planting stock in accordance with this plan.

Many States, including some in this region, are employing extension foresters in cooperation with the Federal Government under the Clarke-McNary law, to assist owners in carrying out the most effective technical methods of managing and improving forest land. Furnishing such advice and assistance is a logical State activity. There are also many foresters connected with State and private forest schools and State forestry departments. These men, as well as the United States Forest Service, are able to assist private owners in solving their forest problems.

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